DEVELOPMENT OF A RECLAMATION TECHNOLOGY

FOR THE

FOOTHILLS/MOUNTAINS REGION OF ALBERTA

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ABSTRACT

Initiated in 1972, an on-going reclamation study has been conducted by the Soils Department of the Alberta Research Council on behalf of Smoky Coal Ltd. at their open-pit mine operations near Grande Cache, Alberta. The main objective of the project is to determine methods of establishing long-term cover that is in harmony with adjacent, undisturbed areas. During the study the unmined and reconstructed soils were characterized. Results of plot studies to determine the suitability and adaptability of various agronomic and native grasses and legumes suggest recommended species for use in the region. Methods for the establishment of trees and shrubs are presented. Encroachment by native species into the reclaimed areas and the use of these areas by wildlife are described. The results obtained to date from the research effort have been successfully transferred to the operational scale.

INTRODUCTION

The Alberta Research Council, Soils Department has been conducting a reclamation research program in the Grande cache area on behalf of, and funded by, Smoky River Coal (formerly McIntyre Mines Ltd.) since May, 1972. When the Alberta Research Council (ARC) undertook the project, reclamation research was truly in its infancy in Alberta. Techniques developed elsewhere, primarily in the United States, were not applicable to the Alberta situation. Furthermore, the issue of reclamation in Alberta was not formally addressed until the Land Surface Conservation and Reclamation Act of 1973 and the Coal Policy of 1976. This paper provides a summary of the work undertaken and an assessment of the results obtained. Results obtained thus far in this study provide a basis for a reclamation technology or the methodology for achieving reclamation success in the Foothills/Mountains region. Details relating to the various aspects of the study are documented in the progress reports prepared annually (see reference list).

Setting

The operations of Smoky River Coal Ltd. are located approximately 13 km north of the town of Grande Cache in the Rocky Mountain Foothills. The two major surface mining operations are the No. 8 and No. 9 Mine areas located adjacent to the Smoky River and Sheep Creek respectively. Elevations range from 1600 to 1800 m and the topography is steeply sloping. Climate can be considered one of the major limiting factors to revegetation success. Frost and/or snow can and do occur in any month of the year and wind is a common phenomenon.

Objectives

The original objectives of the project were defined as follows. New ones were added as additional needs were identified.

1) Characterize unmined and reconstructed soils and evaluate their suitability for reclamation purposes;

2) Determine, by field testing, suitable grasses and legumes for establishment of a protective vegetation cover on reclaimed areas to minimize erosion;

3) Determine, by field and laboratory testing, the nutrient requirements for maintaining a viable vegetative cover;

4) Determine methods of establishing a long-term vegetative cover that is in harmony with adjacent, undisturbed areas.

MATERIALS AND METHODS

Coal production from the No. 8 Mine commenced in June, 1971. The research program that placed emphasis on soils and vegetation concerns began in May, 1972.

Pre-Mining Soils

A soil survey of that portion of the No. 8 Mine area that had not yet been disturbed by mining and the No. 9 Mine area indicated that the soils were dominantly Luvisolic and Brunisolic (CSSC 1978). The depth of salvageable material overlying bedrock ranged from less than 10 cm to in excess of 1 m with an overall average of approximately 50 cm. Analytical data indicated that these soils were moderately to slightly acid, medium textured and had low levels of available plant nutrients, especially nitrogen and phosphorus

Materials Handling Procedures

Soil salvage is an integral part of the materials handling program associated with the overall mining operation. Following the removal of merchantable timber, the soil overlying consolidated bedrock is removed in one lift in a manner such that a minimum amount of coarse fragments are incorporated. The soil materials are stockpiled for future use. Because the surface or organo-mineral horizons are minimal or nonexistent and the sola are quite variable in thickness, segregation or selective handling of soil materials is not considered.

Soil material is replaced on the spoil surface by scrapers or truck/caterpillar operations following the removal of overburden and coal and subsequent backfilling and grading. Scrapers tend to allow for a more uniform depth of soil replacement but they are limited by slope angle and they cause more severe compaction under moist conditions. Caterpillars are not as versatile as scrapers, however their tracks provide excellent seed germination sites.

Reconstructed (Post-Mining) Soils

The reconstructed soils that are developed do not duplicate the soils that existed prior to disturbance. The physical properties of the soils are the ones most drastically altered by the mining process. Soil structure is completely destroyed. Compaction by heavy equipment reduces pore space and makes the soils somewhat less pervious to water, roots and air. The silt loam texture combined with very low levels of organic matter results in a crusting problem which has a direct bearing on infiltration capacity and processes such as runoff and erosion. Infiltration tests indicated that the undisturbed or virgin soils had considerably higher infiltration rates than the reconstructed soils.

Overall, reconstructed soils are generally coarser textured, higher in pH and lower in available nutrients than unmined soils. These soils have some limitations, however, with proper management they are invaluable in achieving reclamation success.

Vegetation Studies

As was stated previously in the list of objectives the overall goal of the project was and is to establish long-term self sustaining cover that is in harmony with the adjacent undisturbed area. Erosion control was one of the initial considerations relative to establishment of a plant cover.

Therefore, a specific end land use(s) was not developed at the time the project was initiated. Instead, the idea was to first establish an

erosion control cover and then get the area back to the original cover which suggested a forest cover not necessarily merchantable along with some capability for wildlife use.

The vegetation aspect of the study was initiated in May, 1972 with the establishment of three plot areas, the first of many to be utilized during the project term. The three locations involved 60 individual 6 x 9 m plots to determine the suitability of 30 different agronomic grasses and legumes. Slopes ranged from 0 to 40 degrees.

Fertilizer trials were included to determine the most appropriate fertilizer types and analyses to be used, as well as timing and rate of application.

A concern relative to utilization of native species was addressed early in the study. It had been suggested that native species be utilized because animals prefer them, that less maintenance is required after establishment and that natives are more aesthetically pleasing. Realistically however in 1972 there was very little "native" seed available. Consequently, seed from loco-weed (Oxytropis spp.), Alpine hedysarum (Hedysarum alpinum), lupine (Lupinus spp.) and Hairy wildrye (Elymus innovatus) was collected in the undisturbed portions of the mine area and subsequently cleaned and planted.

The native species issue was also approached from the standpoint of introducing trees and shrubs relative to meeting the objective of establishing a long term cover that is in harmony with the surrounding area. A major problem was encountered in that seedlings suitable for planting above an elevation of 1100 m were unavailable. Consequently, a cone collection program was undertaken and greenhouse space acquired to rear lodgepole pine (Pinus contorta var. latifolia), engelmann spruce (Picea engelmannii) and white spruce (Picea glauca). Different sizes and types of containers were utilized to determine those most suitable for use in reconstructed soils and to get an appreciation of the relative costs associated with seedling production.

Cuttings of willow (Salix spp.), balsam poplar (Populus balsamifera) and root cuttings of aspen (Populus tremuloides) were rooted in the greenhouse. Direct planting methods were also utilized for the cuttings of willow. Most of the materials produced were then planted within areas having an established grass and/or grass/legume cover.

During the 1983 growing season a limited amount of work was done with direct seeding of pine and spruce seed to determine whether this procedure might be useful to consider on an operational scale. A more extensive field program was undertaken during the 1984 growing season.

RESULTS AND DISCUSSION

Suitability of Agronomic Grasses and Legumes

Most of the agronomics that were planted initially, survived and continue to thrive. Many of the species produced and dropped viable seed. There was some concern at the outset that legumes, and in particular alfalfa, would not adapt or survive at the elevations involved in this study.

Time and annual monitoring of growth resulted in the development of an appreciation of species suitability (desirability), stand composition and fertilizer requirement. For example, with time and the withholding of fertilizers, alfalfa increased its share of the ground cover while the grasses, which tended to comprise a major portion of the initial cover in a mixed stand, declined in vigor. A number of recommended seed mixtures and seeding rates appropriate for different slope aspects (moisture regimes) were developed and are documented in the annual reports prepared (Macyk 1975, 1976, 1977). In terms of the most suitable time of year for planting, it was determined that spring seeding is superior to fall seeding for a number of reasons. The major reason is that legumes, which should be included in the cover established, perform much better when seeded in the spring.

To summarize, one might suggest that legumes such as alfalfa and clover along with the fescues, wheatgrasses, and wildryes are the most appropriate for revegetation use. Bromegrass and timothy provide good initial cover but tend to be highly competitive in mixtures and have relatively high nutrient requirements. Furthermore, the relatively large amounts of vegetative material produced by these species tends to support and promote the mouse population through late fall and winter.

Fertilizer Requirements

As indicated previously, the available nutrient levels of the undisturbed and reconstructed soils was quite low. The grasses and legumes showed a marked response to the application of fertilizers to the extent that

fertilized plots produced 10 to 20 times more dry matter than the unfertilized plots.

A number of concerns surfaced relative to the use of fertilizers in reclamation. Firstly, there was the concern that large applications of fertilizer would be required annually to maintain the established cover. Furthermore, the original cover established was relatively dense which it was suggested would preclude invasion by natives and that resultant dead plant material would create a fire hazard in spring. The dead plant material probably does create a fire hazard but it is also useful from the standpoint of improving the organic matter status of the reconstructed soil.

On the basis of long term observations it can be stated that refertilization is not required annually to maintain a viable vegetative cover. Furthermore, a summary relative to timing of applications was developed and follows:

1) fertilizers should be applied at the time of seeding (year 1) and the following year (year 2);

2) for areas seeded to mixtures comprised of grass only, refertilization should take place in year 3 and every three years thereafter;

3) for areas where legumes such as alfalfa are included in the mixture, the vegetation cover can be left for five years and perhaps longer without refertilization.

Native Species Trials

Results indicated that the seed of some of the native grasses and legumes collected had relatively low germination rates. For example, the germination rate for loco-weed was 70 percent, whereas that of alpine hedysarum was 15 percent. It was observed that establishment of a viable erosion control cover utilizing natives only, took at least two years longer than when agronomics were used. Despite some of the limitations

associated with utilizing natives, the species used in this study are considered appropriate for large scale use. A major concern relates to the acquisition of an adequate seed supply.

Relatively good success was achieved in terms of tree and shrub establishment. It was demonstrated that trees and shrubs will thrive in areas initially seeded to grasses and legumes. This practice was questioned initially because of an anticipated competition for moisture. It became apparent that the protection afforded the seedlings by the grass and legume cover, especially in holding snow in the winter, far outweighed the negative aspects of competition for moisture during the growing season.

Furthermore, it was noted that seedlings growing in association with alfalfa appeared more healthy and vigorous than those growing in association with grasses.

The following summary represents an assessment of results five years after the initial planting of trees and shrubs.

1) engelmann spruce survival rate - 65%
2) lodgepole pine survival rate - 50%
3) rooted willow and balsam cutting survival rate - 65%
4) direct planted willow cutting survival rate - 40%
5) container grown conifer seedlings are superior to bare root stock in terms of survival and growth rate
6) larger size containers promoted higher survival rates.

The issue of container vs bare root stock requires re-evaluation from the standpoint of growth rate.

Some problems were encountered relative to seedling mortality. Upon investigation of some of the seedlings that had expired, it became apparent that the upper root mass surrounded by the peat from the original container was exposed at the soil surface. This exposure is likely the result of frost heaving.

Direct seeding of spruce and pine seed has shown some promise, however assessment of the results of the 1984 field program will be required before any conclusions can be reached or recommendations made.

Recently, emphasis was placed on assessing some of the characteristics of trees planted in the reclaimed area and relating this to trees found in the adjacent forest and in areas reforested after harvesting operations.

In 1983, an assessment of the characteristics of trees planted in the reclaimed area relative to trees present in the adjacent forest was undertaken. Trees selected for examination or comparison were chosen on the basis of obtaining a similar species and sizes from both the natural and reclaimed areas. Trees were excavated to allow for examination of rooting habit and depth. Stem diameter at the base, age and height of each individual tree were determined.

Roots were concentrated in the upper 30 cm of the soil with only minor rooting below 50 cm for both spruce and pine within the reclaimed and undisturbed areas. Rooting habit or pattern was quite similar for trees excavated from the undisturbed and reclaimed areas.

The data obtained indicated that the growth rate for trees in the reclaimed area was considerably greater than that of trees growing in the natural forest. These results might be explained by the fact that the trees in the reclaimed setting may have benefitted to an extent from the fertilizers applied to the accompanying grass cover. Furthermore, the trees in the reclaimed area likely receive more direct sunlight than the trees in the natural forest setting. However, it should be pointed out that the trees in the reclaimed area are more exposed to climatic extremes such as wind.

In 1984, an attempt was made to compare the growth of trees in the reclaimed area with those growing in reforested areas that had previously been logged for pulp industry purposes. It was felt that this might provide a more valid comparison of growth since the reforested areas are more open to light etc. A site was selected approximately 40 km south-

east of No. 8 Mine. The elevation of 1500 m is somewhat less than that of the mine but it was the highest or best that could be readily accessed. The data in Table 1 provide a comparison of results for the different locations.

Table 1 Age and Growth Data for Conifers

Treatment/Location	N*	Diameter (cm)	Height (cm)	Age (yrs)
Reclaimed–No. 8 Mine				
Spruce	12	1.4	55	11
Pine	12	2.6	75	11
Reforested				
Spruce	17	1.2	52	14
Pine	18	1.3	59	11
Natural Forest – No. 8 Mine				
Spruce	23	0.9	42	17
Pine	26	3.1	108	28

N* – number of trees

The data presented suggest that the trees growing in the reclaimed area are at least comparable to those in the reforested and the natural forest settings. It should also be noted that climate is more severe at the No. 8 Mine than at the location from which the reforested trees were obtained.

Encroachment by Natives

Field observations indicate that encroachment by natives into the disturbed areas will occur with time. Various lichens, mosses, lupine, loco-weed, alpine hedysarum and Indian paintbrush are naturally invading the areas initially seeded to agronomics. Willow, alder, balsam poplar and the conifers, dominantly spruce, pine and subalpine fir are also found in the area.

The encroachment by natives is the result of seed spreading from adjacent undisturbed areas and/or the result of incorporation of seed and vegetative material during soil salvage operations and the resultant germination of seed or sprouting of vegetative material following soil replacement.

These observations suggest that revegetation can be planned and managed in a manner such that natives can be included in the original seed mix and they can be expected to encroach or invade on their own. In other words, natives grasses, legumes, herbs, shrubs or trees will come in naturally if not planted originally. However the appropriate seeding or planting of natives speeds up the overall process.

Wildlife Utilization of Reclaimed Areas

During the initial stages of the study it was suggested that most wildlife species would not utilize reclaimed areas especially those where agronomic grasses and legumes were utilized. Bighorn sheep initially inhabited the experimental areas only in spring because the plots greened up earlier than their native range. Presently, they stay within the reclaimed area throughout the growing season, selectively grazing particular species such as alpine bluegrass, creeping foxtail, hard fescue and to some extent the tender shoots of alfalfa.

Transfer of Research Results to Operational Scale

The results of the experimental work were applied on a large scale early in the project; revegetation of major areas began in the fall of 1973, 16 months after the inception of experimental work. Seed mixtures and fertilizer applications were based on results available at that time and have been upgraded annually as more information became available. It was determined that hand broadcast of seed and fertilizer was more effective and had a higher cost-benefit than to hydroseeding and helicopter seeding. One troublesome aspect of going to the large scale involved that of incorporating the seed by roughening or scarifying the surface following the broadcast application. On a plot scale this was accomplished by hand raking, whereas for the large scale, several designs of a "drag" were

prepared before one was built which was both suitable and adequately sturdy.

CONCLUSIONS

The results of the research project described suggest that reclamation in the Foothills/Mountains region of Alberta can be successful provided that certain techniques are utilized and specific procedures followed. The key requirements follow:

1) Soil salvage and replacement is practiced.

2) Appropriate agronomic grasses and legumes are selected to provide initial cover. Native species can be included in the mixtures.

3) Fertilization is practiced in a manner that allows for stand maintenance but also allows for desirable species competition and for encroachment by natives.

4) Appropriate seedling stock, cuttings, etc. are used for establishment of trees and shrubs. Some of the species will come in naturally but perhaps not in the density and certainly not as quickly as compared to plantings. More research is required to determine the merits of direct seeding of conifer seed to establish acceptable stands.

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NINTH ANNUAL MEETING CANADIAN LAND RECLAMATION ASSOCIATION

RECLAMATION IN MOUNTAINS, FOOTHILLS AND PLAINS: **DOING IT RIGHT!**

AUGUST 21-24, 1984
Calgary, Alberta, Canada

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CANADIAN LAND RECLAMATION ASSOCIATION
PROCEEDINGS OF THE NINTH ANNUAL MEETING

TABLE OF CONTENTS

Wednesday, August 22

Thursday, August 23

13. Managing Minesoil Development for Productive Reclaimed Lands
(W. SCHAFER)

14. Reclamation Monitoring: The Critical Elements of a Reclamation Monitorin Program
(R.L. JOHNSON, P.J. BURTON, V. KLASSEN, P.D. LULMAN, D.R. DORAM)

15. Plains Hydrology and Reclamation Project: Results of Five Years Study
(S.R. MORAN, M.R. TRUDELL, A. MASLOWSKI-SCHUTZE, A.E. HOWARD, T.M. MACYK, E.I. WALLICK)

16. Highvale Soil Reconstruction Reclamation Research Program
(M.M. BOEHM, V.E. KLASSEN, L.A. PANEK)

17. Battle River Soil Reconstruction Project: Results Three Years Afte Construction
(L.A. LESKIW)

18. Gas Research Institute Pipeline Right of Way Research Activities
(C.A. CAHILL, R.P. CARTER)

19. Subsoiling to Mitigate Compaction on the North Bay Shortcut Project
(W.H. WATT)

20. Effects of Time and Grazing Regime on Revegetation of Native Range Afte Pipeline Installation
(M.A. NAETH, A.W. BAILEY)

21. Revegetation Monitoring of the Alaska Highway Gas Pipeline Prebuild
(R. HERMESH)

22. Post-Mining Groundwater Chemistry and the Effects of In-Pit Coal Ash Disposal
(M.R. TRUDELL, D. CHEEL, S.R. MORAN)

23. Assessment of Horizontal and Vertical Permeability and Vertical Flow Rates fo the Rosebud - McKay Interburden, Colstrip, Montana
(P. NORBECK)

24. Accumulation of Metals and Radium - 226 by Water Sedge Growing on Uranium Mi Tailings in Northern Saskatchewan
(F.T. FRANKLING, R.E. REDMANN)

25. How Successful is the Sudbury (Ontario) Land Reclamation Program?
(P. BECKETT, K. WINTERHALDER, B. McILVEEN)

26. Methodology for Assessing Pre-Mine Agricultural Productivity
(T.A. ODDIE, D.R. DORAM, H.J. QUAN)

27. An Agricultural Capability Rating System for Reconstructed Soils
(T.M. MACYK)